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ABSTRACT

This study explores a technique for evaluating teacher education programs in terms of teaching competencies, as applied to the Indiana University Mathematics Methods Program (MMP). The evaluation procedures formulated for the study include a process product design in combination with a modification of Popham's performance test paradigm and Gage's adaptation of the microteaching concept. Ten preservice elementary education majors were randomly selected from the MMP and from the Mathematics Education Component of two alternative programs of teacher education (Contrast I and Contrast II) at Indiana University. Each preservice teacher (PST) was placed in a videotaped miniteaching situation where pupil learning was the criterion of effectiveness. Three teaching variables--Clarity, Questioning, and Involvement--were analyzed, and PST mathematics knowledge relative to the teaching topic was assessed. The model yielded consistent and useful information in a short time span and in a relatively objective manner. The three dimensions of teaching style correlate highly with pupil achievement and MMP trainees achieved higher mean performance scores than other PSTs on teaching style and pupil achievement variables. Finally, pupils taught by MMP and Contrast II trainees achieved higher adjusted scores than those taught by the Contrast I group, which had no field experience in conjunction with their program of training. (DMT)

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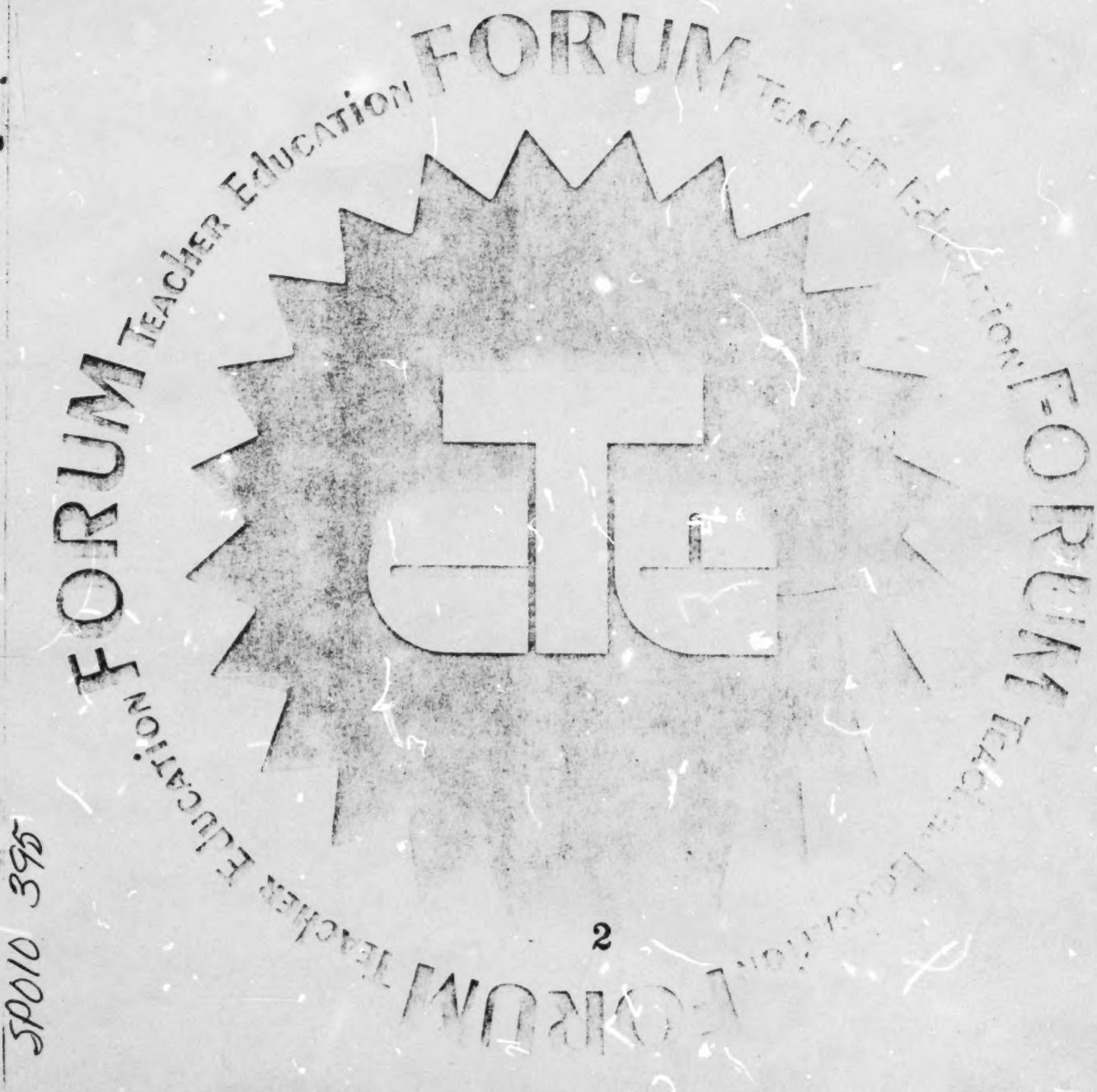

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AN EVALUATION MODEL APPLIED TO A MATHEMATICS-METHODS PROGRAM INVOLVING THREE CHARACTERISTICS OF TEACHING STYLE AND THEIR RELATIONSHIP TO PUPIL ACHIEVEMENT

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A B S T R A C T

This study explored a technique for evaluating teacher education programs in terms of teaching competencies. The evaluative procedures involved a process-product design in combination with a modification of Popham's performance test paradigm and aspects of the microteaching concept, and were applied to the Indiana University Mathematics-Methods Program (MMP). Ten preservice elementary education majors were randomly sampled from the MMP and from the mathematics education component of two alternative programs of teacher education at Indiana University. Each preservice teacher (PST) was placed in a videotaped mini-teaching situation where pupil learning was the criterion of effectiveness. Three teacher variables were also analyzed and PST mathematics knowledge relative to the teaching topic was assessed. Significant differences between groups occurred in both the multivariate and subsequent univariate analyses. Significant correlations between the three teacher variables and pupil achievement were also found, encouraging further study in these areas.

One vital and crucial element which should accompany the development of teacher education programs--and one which is often neglected, is that of program assessment or evaluation. Elam (1971), speaking for the American Association of Colleges for Teacher Education, cited evaluation attempts as one of the weakest elements in teacher education. However, in reviewing the state of research related to teacher education, Peck and Tucker (1973) noted that both the quality of design and the reporting of such research have improved since the mid-sixties. In particular, the use of observation instruments (category systems, rating scales) or some adaptation of the microteaching technique in recent research studies have helped educators to focus more clearly on and to delineate more carefully components of teacher/pupil behavior in the interactive setting. Further, an increasing number of process-product studies has been noted. These investigations, which relate teaching (process) behaviors to pupil outcome (product) measures, have been extensively reviewed by Rosenshine and Furst. In a 1973 AERA publication these educators reported nine variables which appear to have yielded the most significant and consistent correlations between aspects of teaching strategy or style and measures of student growth: clarity of presentation, variability, enthusiasm, task orientation, teacher indirectness, student opportunity to learn criterion material, teacher use of structuring comments, teacher use of multiple question types, and an absence of criticism.

At the 1973 symposium of the American Educational Research Association, Popham described a teaching "performance test" paradigm which assesses teacher competency in terms of pupil achievement. In Popham's model a teacher is given a set of instructional objectives, prepares and teaches a mini-lesson to a small group of students in an effort to meet those objectives, and is subsequently evaluated in terms of the amount of learner growth he or she is able to effect. Popham's paradigm is based on the idea that a teacher education program is as good as the teachers it produces. Since his paradigm provides an assessment of teacher competency to meet prespecified objectives, the assessment simultaneously validates the program which set out to promote such teacher abilities.

Popham's paradigm, however, concentrates only on product or outcome measures of teaching. Teacher educators also have a vested interest in process or teaching behaviors which are influenced by their program experiences and activities. Therefore, a slight modification of Popham's design, one which permits the study of specific teacher variables as well, is desirable. The use of videotape to record the teaching performance test, for example, makes possible the analysis of teacher variables and their relation to pupil learning without distorting Popham's basic paradigm. Gage (1968) has described this use of videotaping as an adaptation of the microteaching concept. Allen (1966;297), who coined the term, refers to microteaching as a mini-teaching encounter, one scaled down in terms of class size (1-5 pupils) and time (5-20 minutes). Elsewhere, Allen and Ryan (1969) state that microteaching is real teaching. The technique,

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however, lessens the complexities of normal classroom teaching and makes possible the focusing upon specific teaching behaviors. Microteaching commonly involves a teach-reteach cycle, where videotape feedback is used to facilitate growth in teaching skills. In adapting the microteaching concept to process-product research, one can use the videotape feature to record the teaching session(s) for subsequent analysis of specific teaching behaviors.

The purpose of the present study was to explore a technique for evaluating teacher education programs in terms of teaching competencies, and, in particular, to explore that technique as applied to the Indiana University Mathematics-Methods Program. The evaluation procedures formulated for the study involve a process-product design in combination with a modification of Popham's performance test paradigm and Gage's adaptation of the microteaching concept. Such a combination makes possible an in-depth analysis of specific teaching behaviors as well as an assessment of pupil learning which can be related to the teaching.

More specifically the evaluation technique involves:

1. The identification of teacher variables (skills and/or strategies)
   a. which research has shown to be consistently related to pupil cognitive/affective growth; and
   b. which are related to the teacher education program's philosophy or content materials.

2. The utilization of Popham's performance test paradigm to place teachers from alternative programs in a mini-teaching situation (specific to the content field) where learner growth is the criterion of effectiveness.

3. The videotaping of the teaching session(s) so that an in-depth analysis of the teacher variables identified in (') can be facilitated.

In order to explore the effectiveness of the evaluation model, the procedures outlined above were used to assess the Indiana University Mathematics-Methods Program, an innovative program in mathematics education which has had nationwide impact. The present study dealt only with the MMP component at Indiana University (1973-74 academic year), where the Program was implemented in two pilot classes as a 12-hour, two-semester course. Program experiences offered elementary preservice teachers an activity-oriented, field-based program with integrated focus on both mathematics and relevant teaching methods.

Three of the variables identified by Rosenshine and Furst (1973): (1) clarity of presentation, (2) teacher use of multiple question types, and (3) teacher indirectness, were chosen as the bases for analyzing the teaching styles and strategies of the preservice elementary teachers participating in this investigation. A slight rephrasing of the above variable names was used, however, to emphasize the connotation given them in the study: (1) clarity in developing a mathematical idea (Clarity), (2) inquiry questioning techniques (Questioning), and (3) encouragement of constructive pupil involvement (Involvement).

Three factors motivated the choice of these dimensions of teaching style/strategy. First, research has shown them to be consistently related

to pupil cognitive growth. Second, of the variables identified by Rosenshine and Furst, these can be traced to elements in the philosophy and/or written materials of the Mathematics-Methods Program (Dodd, 1974). Third, it is possible to code behaviors specific to these variables during a mini-teaching session such as that suggested by Popham's performance test.

The study was designed to analyze these three dimensions of the teaching style of preservice teachers (PSTs) from the Mathematics-Methods Program and from the mathematics education component of two alternative teacher education programs at Indiana University. The mathematical knowledge of the preservice teachers relevant to the topic of the mini-teaching sessions was also assessed (PST Test). In addition the relationship between these four teacher variables and mean adjusted pupil scores (Pupil Score) was also investigated.

Two major questions were asked: (1) Is there any difference in the performances of preservice teachers from the Mathematics-Methods Program and from the two alternative programs, on the multivariate composite or in the univariate analyses, of the following dependent measures: Clarity, Questioning, Involvement, PST Test, Pupil Score? (2) Is there any relationship between the mean adjusted achievement scores of pupils taught by the PSTs and the other four dependent variables?

METHOD

Subjects

The population of preservice teachers for the study consisted of undergraduate elementary education majors from the Mathematics-Methods Program (MMP) and from the mathematics education component of two alternative teacher education programs (Contrast I and Contrast II) at Indiana University. The Mathematics-Methods Program provides an integrated program of mathematics and related teaching methods instruction in combination with regular elementary school experiences in teaching mathematical topics. Trainees in the other two programs had previously completed the required mathematics courses for teachers and were currently enrolled in a course of methods of teaching elementary mathematics. The Contrast I group had no field experiences in conjunction with their course. On the other hand, Contrast II trainees regularly participated in school experiences. The field experiences of this latter group were, however, more general in nature than those of the MMP group, and were not restricted to teaching mathematical topics to children. Ten preservice teachers were randomly sampled from each of the programs: MMP, Contrast I, and Contrast II.

Third grade pupils from Rogers and University Elementary Schools in Bloomington, Indiana provided the school population. The sample consisted of 80 out of 92 University pupils and 40 of 66 Rogers School students. The schools were chosen because of the similarity of the socio-economic background of pupils and the extensive videotaping facilities at University School. A major portion of these pupils were children of professional businessmen or of Indiana University graduate students or faculty. Average I.Q. of pupils was 120.

Instrumentation

Both written and observation instruments were constructed by the investigator for the study. The three written tests: Fraction Inventory (for school pupils), Pupil Equivalent Fraction Posttest, and PST Equivalent Fraction Test were each content validated by faculty members of the Indiana University Mathematics and Mathematics Education departments, and piloted with several groups prior to the study. Reliability studies were carried out for each test and an $\alpha \geq .84$ was obtained for each test prior to its use in the investigation.

Three observation instruments and accompanying coders' guides were developed by the investigator which specified the characteristics of behavior that defined each of the three teacher variables Clarity, Questioning, and Involvement for the study. The major categories of each of these instruments are listed below.

Major Categories of the Three Observation Instruments

1. Clarity in Developing a Mathematical Idea (rated)
   a. Mathematical objectives of the lesson are identifiable
   b. Lesson is well planned and executed
   c. Instruction builds upon previous learning and experiences
   d. Models and illustrations are effectively used
   e. Flow of ideas from instructor to pupils is understood
   f. Evaluation is on-going, to check that ideas are clearly grasped

2. Inquiry Questioning Techniques
   a. General questioning moves of the preservice teacher (rated)
      1. Used questioning rather than exposition as basic strategy
      2. Sequences questions appropriately
   b. Inquiry questions asked by the preservice teacher (counted)
      1. Systematic observation
      2. Rationalization
      3. Higher order extension of new learning

3. Encouragement of Constructive Pupil Involvement
   a. Elicits student ideas which relate to important ideas in the lesson sequence (counted)
   b. Relates learning to child's world (counted)
   c. Builds upon student response (counted)
   d. Encourages activities which promote self-learning within the lesson (counted)
   e. Structures lesson so pupils are actively participating in a manner which facilitates learning of the mathematical concepts relevant to the lesson. (rated)

Four graduate students were trained as observers to view and code the videotaped teaching sessions of the PSTs who participated in the study. Videotapes from a pilot study were used to train coders. The training sessions focused on one variable at a time and allowed for open discussion until questions were answered and the interpretation of behaviors for various categories of an instrument and accompanying coder's guide was agreed upon by all coders. When coders were confident of the coding procedures for each of the teacher variables, they independently coded two of the training tapes. Each coder viewed each tape

twice. At one viewing the teacher's questioning style was observed and coded. At another viewing the coder concentrated upon the preservice teacher's encouragement of constructive pupil involvement. Having viewed a tape twice, the coder then assigned a clarity rating to the PST involved. Since the average of the scores assigned to a PST on a variable was recorded as the dependent measure, the procedure outlined by Snedecor (Ebel, 1967;116-119) for average ratings was used to test inter-coder reliability. A criterion of .80 was set. The initial training sessions were considered complete when this criterion was met for each variable coded. The 30 videotapes were randomly assigned to coders in such a manner that each tape was independently coded by two different persons. Both inter-coder and intra-coder reliability was calculated at periodic intervals throughout the time tapes were being analyzed.

Procedures

Prior to the teaching sessions each preservice teacher took the researcher-constructed PST Equivalent Fraction Test. The Kuhlmann-Anderson I.Q. Test (Form CD) and the Fraction Inventory were also administered as pretest measures to the third grade pupils of University and Rogers Elementary Schools. These latter two measures were used to adjust pupil posttest scores for initial differences in learning ability and knowledge of fractions.

Popham's performance test paradigm provided the framework for the subsequent teaching sessions:

1. Three days prior to teaching, each preservice teacher was given a list of instructional objectives for the two half-hour sessions he or she was to prepare and teach to a group of four third grade pupils. The topic was "equivalent fractions;" the lesson was introductory in nature. A summary of pupils' background work with fractions was also given to the PSTs.

2. Each preservice teacher had three days to prepare his/her teaching sessions. He or she was asked to do so independently, rather than solicit peers or instructors for help.

3. Each preservice teacher taught, on two consecutive days, his/her preplanned lesson to the group of 4 third graders randomly assigned to him/her. Each of the two half-hour sessions was recorded on videotape for subsequent analysis by coders.

4. On the day following the second teaching session, students took the Pupil Equivalent Fraction Posttest. Adjusted group posttest scores were used as an estimate of the preservice teacher's effectiveness during instruction.

By means of the written tests and analysis of the videotaped teaching sessions, the following five dependent measures were obtained for each preservice teacher: PST Equivalent Fraction Test score, clarity rating, questioning index, constructive involvement score, and mean adjusted pupil score. The number of correct responses on each of the two written tests was calculated. For the PST Equivalent Fraction Test, this score was

used as the dependent measure. Further, for each preservice teacher, the adjusted group mean performance of his/her four pupils on the Pupil Equivalent Fraction Posttest was entered as a dependent measure. The average numeric sum of frequency counts and ratings recorded by the trained observers (using the three observation instruments and coders' guides) provided, respectively, a clarity rating, questioning index, and constructive involvement score for each preservice teacher.

RESULTS

Reliability Studies

Satisfactory reliability information is necessary to support the credibility of data gathered from the instruments and to lend substance to interpretations or conclusions based on the analysis of that data. For this reason four reliability studies were carried out for the study, one for each of the researcher-constructed written instruments as well as a special study of coder consistency. The computer program TESTAT from the Indiana University Educational Statistics library was used for the analysis of the written tests. The alpha coefficient of internal consistency exceeded .83 for each of the tests. The Snedecor formula for average coder scores was used to determine both intra- and inter-coder reliability. The lowest reliability estimate obtained was .87 (against the criterion .80), indicating the coders were generally consistent with themselves and with each other.

Tests of Hypotheses Associated with Group Differences

To test differences between groups (MMP, Contrast I, Contrast II) on the five dependent variables, a completely randomized one-way multivariate design with 10 subjects per cell was used. A subsequent univariate analysis was performed on each dependent variable.

The mean scores and standard deviations of the five dependent variables for each of the three groups of preservice teachers are given in Table 1. Mean scores are presented in both raw and standardized form.

TABLE 1

Means and Standard Deviations
of the Three Groups of Preservice Teachers

	MMP	Contrast I	Contrast II
Raw Score Means:			
PST Test	18.50	16.30	16.70
Clarity	32.65	19.50	25.55
Questioning	52.05	29.65	41.25
Involvement	59.00	36.85	45.35
Pupil Score	2.11	-2.17	.16

	MMP	Contrast I	Contrast II
Standard Score Means:			
PST Test	.36	- .23	- .13
Clarity	.83	- .87	.05
Questioning	.59	- .61	.01
Involvement	.79	- .67	- .11
Pupil Score	.82	- .87	.05
Raw Score Standard Deviations:			
PST Test	3.84	3.71	3.65
Clarity	9.15	5.64	5.16
Questioning	20.38	10.57	17.87
Involvement	16.01	9.92	10.48
Pupil Score	2.12	1.61	1.80

*The mean adjusted pupil scores reported are residual gain scores. The Statistical Package for the Social Sciences computer program REGRESSION was used to compute the scores with I.Q. and Fraction Inventory scores as the predictor variables.

Table 1 indicates that the rank order of mean performances on the five dependent variables of the study was constant. Preservice teachers from the MMP group performed highest, Contrast II PSTs ranked second, and PSTs from Contrast I performed lowest on all five variables.

The multivariate F test reported in Table 2 indicated a significant variation among the mean vectors for groups with a p value less than .011. This table also presents univariate F statistics for each of the dependent variables. The univariate analyses are supported by Cramer and Bock (1966), who state that a significant multivariate statistic justifies an investigation of separate univariate F tests for the corresponding variables. Significant differences among groups occurred for the variables Clarity, Questioning, Involvement, and Pupil Score. No significant differences were obtained among groups for the variable PST Test.

TABLE 2

Multivariate and Univariate Analyses
of Variance for Hypotheses Testing Group Differences

Dependent Variable(s)	Test	df	F	p<
PST Test, Clarity, Questioning, Involvement, Pupil Score	M	10, 46	2.708	.011
PST Test	U	2, 27	.084	.387
Clarity	U	2, 27	9.144	.001
Questioning	U	2, 27	4.446	.021
Involvement	U	2, 27	8.062	.002
Pupil Score	U	2, 27	13.375	.001

Multiple comparisons between group means were also carried out for significant univariate F statistics. The Tukey procedure was chosen to decide which groups of preservice teachers were responsible for the significant F ratios since this method provided for pairwise comparisons of means for groups of equal size (Hopkins and Chadbourn, 1967). This latter analysis indicated that PSTs from the Mathematics-Methods Program performed significantly higher than Contrast I on all four variables ($p < .05$), and higher than Contrast II on Clarity, Involvement, and Pupil Score ($p < .10$). In addition, PSTs from Contrast II (the group with a school experience component) performed significantly better on the Pupil Score variable than did Contrast I trainees (no school component).

Tests of Hypotheses Which Investigated Correlation Between Variables

Pearson product moment correlations were computed to determine the relationships of pupil achievement with the other four teacher variables. The correlations between Pupil Score and the variables Clarity, Questioning, Involvement, and PST Test are presented in Table 3. Three variables in this table (Clarity, Questioning, Involvement) are significant correlates of Pupil Score and, in addition, are significantly correlated with each other ($p < .01$).

TABLE 3

Correlations Between Mean Adjusted Pupil Scores and the Other Dependent Variables Used in This Study

	PST Test	Clarity	Questioning	Involvement
Clarity	.34*			
Questioning	-.11	.70**		
Involvement	.15	.79**	.83**	
Pupil Score	.26	.96**	.71**	.75**

*$p < .05$
**$p < .01$

An extremely high correlation occurs between Clarity and Pupil Score (.96). The variable PST Test showed no significant correlation with the criterion, Pupil Score.

DISCUSSION

The present study explored a technique for evaluating teacher education programs in terms of the exhibited competencies of its trainees. Several conclusions, based upon the results of this exploration, may be stated.

1. The procedures used in this study should be considered a viable technique for evaluating segments of a teacher education program.

2. The three teacher variables Clarity, Questioning, and Involvement are strong correlates of pupil achievement.

3. The Mathematics-Methods Program appears to have promoted competencies associated with the variables Clarity, Questioning, Involvement, and Pupil Score more effectively than the other two programs of the study.

4. There is an indication that regular, planned school experience in conjunction with the mathematics preparation of preservice elementary teachers may have an impact on teacher competency to produce mathematical learning in children.

The evaluation model proposed and explored in this investigation yielded consistent and useful information for a specific teacher education program, and did so within a short time span and in a relatively objective manner. These factors encourage further use of the technique in the evaluation of other teacher education programs. The three dimensions of teaching style chosen for analysis in the present evaluation correlated highly with pupil achievement. These results parallel other findings in educational research (see Rosenshine, 1973).

While MMP trainees achieved higher mean performance scores than other PSTs on the teaching style and pupil achievement variables, a more detailed and rigorous analysis of components of the Mathematics-Methods Program is necessary before definitive conclusions comparing these programs can be drawn. Certainly present results would support such efforts.

Conclusion 4 lends some support to the current trend to include field experiences in teacher education programs. In the present study pupils taught by MMP and Contrast II trainees achieved higher adjusted scores than those taught by the Contrast I group, which had no school experiences in conjunction with their program of training. The school experiences of the MMP trainees were specific and followed a definite sequence laid out by their field instructors. Those of the Contrast II group, on the other hand, were more general in nature and were not limited to teaching mathematical topics. The mean adjusted pupil scores of MMP trainees were higher than those of Contrast II PSTs at the .10 significance level. It would be interesting to explore these differences in the nature of field experiences more rigorously and systematically in order to assess the effectiveness of various types of such experiences on pupil achievement.

Finally, several limitations of the generalizability of results are recognized. The evaluation model formulated in this study deals with only one phase of a program's evaluation: exhibited competency of trainees with respect to specific teacher variables and their ability to promote pupil learning. No attempt at total program assessment was made. An additional limitation is the fact that the sample of preservice teachers was not large. Also, the elementary school population was small and rather atypical. Further, all teaching sessions focused upon one topic (equivalent fractions) at one grade level (grade 3). This arrangement

did not allow for a study of teaching competencies with respect to other mathematical topics nor with children of different age levels. Each of these limiting factors implies a suggestion for further research.

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